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[Title of the Invention] METHOD FOR ASSEMBLING LIQUID CRYSTAL SUBSTRATE

[Abstract]

[Object] There is provided a method for assembling liquid crystal substrate in which the supplied quantities of the liquid crystal agents are maintained accurate, the dispersion time of the liquid crystal agents is made short, and the liquid crystal substrates are bonded in short time, thereby making it possible to enhance the productivity of the liquid crystal substrate.

[Solving Means] A method for assembling liquid crystal substrate is disclosed wherein one of the substrates being bonded is held at a rear surface of the pressing plate, the other of the substrates is held on a table, thereafter both of the substrates are placed to opposes each other, and wherein after supplying a liquid crystal agent on the substrate held on the table, both of the substrates are bonded each other while narrowing the distance therebetween by means of the adhesive agent provided on either one of the substrates. The method is characterized in that: the liquid crystal agent supplied on the one of the substrate that is held on the table and the substrate held at the rear surface of the pressing plate are made contacted to each other, and the liquid crystal agent is in this state dispersed in a

direction where the main surface of the substrate is dispersed by moving either one of the substrates and thereafter the substrates are bonded each other.

[Claims]

[Claim 1] A method for assembling liquid crystal substrate wherein one of the substrates being bonded is held at a rear surface of the pressing plate, the other of the substrates is held on a table, thereafter both of the substrates are placed to opposes each other, and wherein after supplying a liquid crystal agent on the substrate held on the table, both of the substrates are bonded each other while narrowing the distance therebetween by means of the adhesive agent provided on either one of the substrates, the method characterized in that:

said liquid crystal agent supplied on said one of the substrates that is held on said table and said substrate held at the rear surface of said pressing plate are made contacted to each other, and said liquid crystal agent is in this state dispersed in a direction where the main surface of said substrate is dispersed by moving either one of said substrates and thereafter said substrates are bonded each other.

[Claim 2] The method for assembling liquid crystal substrate according to Claim 1, wherein said moving one of

the substrate is being moved in a direction where the main surface of the substrate is dispersed.

[Claim 3] The method for assembling liquid crystal substrate according to Claim 1, wherein in a state where the adhesive agents provided on one of the substrates are not contacted to the other one of the substrate, by making said substrate held at the rear surface of said pressing plate to be contact with said liquid crystal agents supplied on said the other of the substrates that is held on the table, thereby dispersing said liquid crystal agents in a direction where the main surface of the substrate is dispersed.

[Claim 4] The method for assembling liquid crystal substrate according to Claim 1, wherein in a state where said adhesive agents are provided on either one of the substrates such that they have closed patterns thereon, said liquid crystal agents are supplied into said closed patterns with an amount that is thicker than that of said adhesive agents, and the distance between both substrates are narrowed such that both substrates are bonded each other by said adhesive agents.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a method for

assembling liquid crystal substrates where each of the substrates to be bonded is held to oppose each other and the substrates are bonded by narrowing the distance therebetween.

[0002]

[Description of the Related Art]

In producing a liquid crystal display panel, a process is know where two pieces of glass substrate having transparent electrodes or thin transistor arrays attached thereon are bonded by means of adhesive agents (hereinafter will be referred to seal agents) with a very narrow distance therebetween for example about several microns, and thereby sealing the liquid crystal agents on the area formed accordingly.

[0003]

As a method for sealing the liquid crystal agents, the method which is disclosed in a Japanese Unexamined Patent Publication No. S62-165622 has been proposed. In this method, the sealing agents are drawn in closed patterns such that an injection hole needs not be provided in one of the substrates. Further, in a state where the liquid crystal agents are dropped into the closed patterns, the other one of the substrates are placed on the one of the substrates and thereafter the upper and lower substrates are put closer to each other in a vacuum atmosphere whereby bonding the upper and lower substrates.

[0004]

[Problems to be Solved by the Invention]

However, in the conventional method, because the amount of the liquid crystal agents that are supplied into the closed patterns after sealing process increases more than the application amount that was originally required, the liquid crystal agents in some occasions may be over-flown outside of the seal agent. In this case, it may be required to wash the substrates, which will make the high cost liquid crystal agents useless.

[0005]

As a means for supplying a required amount of agents with accuracy, a plunger is commonly used. Because the plunger drops one droplet at a time that is called a droplet number, however, it may require from several minutes to tens of minutes before the liquid crystal agents are dispersed far into the inner side of the patterns.

[0006]

In order to shorten the dispersion time by using a lesser amount of one droplet and narrowing the dispersion regions of the liquid crystal agents, it is required to maintain the required supply amount as a whole by increasing the droplet number. In addition, because the application amount at one droplet number is less in this case, the application amount is likely to be uneven such that the

supply time of the liquid crystal agents is increased by the increased amount of the droplet number.

[0007]

In other words, it is required that the supplied quantities of the liquid crystal agents are maintained accurate and thereby omitting the washing process so that the useless supply of the liquid crystal is prevented, but also required that the dispersion time of the liquid crystal agents is made short and the liquid crystal substrates are bonded in short time thereby making it possible to enhance the productivity of the liquid crystal substrate. However, both of the requirements could not be accomplished in the conventional methods.

[0008]

Therefore, the object of the present invention is to provide a method for assembling liquid crystal substrate in which the supplied quantities of the liquid crystal agents are maintained accurate, the dispersion time of the liquid crystal agents is made short, and the liquid crystal substrates are bonded in short time, thereby making it possible to enhance the productivity of the liquid crystal substrate.

[0009]

[Means for Solving the Problems]

In order to accomplish the above-mentioned objects, the

present invention provides a method for assembling liquid crystal substrate wherein one of the substrates being bonded is held at a rear surface of the pressing plate, the other of the substrates is held on a table, thereafter both of the substrates are placed to opposes each other, and wherein after supplying a liquid crystal agent on the substrate held on the table, both of the substrates are bonded each other while narrowing the distance therebetween by means of the adhesive agent provided on either one of the substrates. The method is characterized in that the liquid crystal agent supplied on the one of the substrate that is held on the table and the substrate held at the rear surface of the pressing plate are made contacted to each other, and the liquid crystal agent is in this state dispersed in a direction where the main surface of the substrate is dispersed by moving either one of the substrates and thereafter the substrates are bonded each other.

[0010]

[Embodiments]

Hereinafter, an embodiment of the present invention will be further described with reference to the attached drawings.

[0011]

In Fig. 1, the substrate assembly apparatus which embodies the present invention is comprised of a liquid

crystal dropping part S1 and a substrate bonding part, which are disposed adjacent to each other on the claw plate 2.

[0012]

A frame 3 that supports the substrate bonding part S2 is disposed on the upper side of the claw plate 2. Moreover, a X, Y, theta stage T1 is provided on the upper surface of the claw plate 2. The X stage 4a constituting the X, Y, theta stage T1 is configured to be movable in X axis that corresponds to a horizontal direction in drawing by means of a driving motor 5. That is, the X stage 4a moves between the liquid crystal dropping part S1 and the substrate bonding part S2. The Y stage 4b is located on the X stage 4a and is configured to be movable in Y axis that crosses X axis by means of the driving motor 5. The theta stage 4c is located on the Y stage 4b and is configured to be rotatable through a rotating bearing 7 in a plane with respect to the Y stage 4b. A table 9 having a lower substrate 1a mounted thereon is fixed on the theta stage 4c. In addition, like the upper substrate that will be described later, the lower substrate 1a is mounted and held on the table 9 by means of a vacuum absorption method or an electrostatic absorption method. Moreover, a lower chamber unit 10 is fixed on the Y stage 4b by means of a plate 13. The theta stage 4c is attached to the lower chamber unit 10 through the vacuum seal 12 such that the theta stage 4c can freely rotate with

respect to the lower chamber unit 10 by means of the rotating bearing 11. The theta stage 4c has a structure that the lower chamber unit 10 does not rotate itself even when the theta stage 4c is rotating.

[0013]

The liquid crystal dropping part S1 is comprised of a dispenser 17 for dropping a desired amount of liquid crystal agents on the lower substrate 1a that is mounted and held on the table 9, a Z axis stage 15 which moves the dispenser 17 vertically, and a driving motor 16 which drives the Z axis stage 15. Here, the dispenser 17 is supported by a bracket 14 that is projected from the frame 3. The X, Y, theta stage T1 having the lower substrate 1a mounted and held on the table 9, moves X and Y directions with respect to the nozzle 18 of the dispenser 17 which drops the liquid crystal agents. With this construction, a desired amount of liquid crystal agents are dropped at an arbitrary position on the lower substrate 1a.

[0014]

The X, Y, theta stage T1 which is mounting and holding the lower substrate 1a where the liquid crystal agents are dropped, moves down to the substrate bonding part S2 by the driving motor 5.

[0015]

In the substrate bonding part S2, the upper chamber

unit 21 and the press plate 27 are configured to be able to move up and down independently and respectively. Here, the press plate 27 has a vacuum absorption function and an electrostatic absorption function. In other words, the upper chamber unit 21 has a housing that contains a linear bush and a vacuum seal. In addition, the upper chamber unit 21 is able to move up and down in Z axis direction by the cylinder 22 fixed on the frame 3 and guided by a shaft 29.

[0016]

As the X, Y, theta stage T1 is moved to the substrate bonding part S2 and the upper chamber unit 21 is lowered, the flange 21a of the upper chamber unit 21 come in contact with an O ring 44 disposed around the lower chamber unit 10 such that they become one body. At this time, they serve as a vacuum chamber. Here, the ball bearing 87 provided around the lower chamber unit 10 serve as adjusting the crush amount of the O ring 44 by the vacuum and is configured to be located at an arbitrary position in a vertical direction. Since the huge force generated from the vacuum is received by the lower chamber unit 10 through the ball bearing 87, the O ring 44 may be deformed by the elasticity. Thus, it is possible to determine the position of the X, Y, theta stage T1 within the elasticity range of the O ring 44 with easiness and precision by moving the X, Y, theta stage T1 gently during bonding process, which will be described later.

[0017]

Even when the vacuum chamber formed by the upper chamber unit 21 and the lower chamber unit 10 is deformed, because housing 30 contains a vacuum seal which does not leaks the vacuum with respect to the shaft 29 and is vertically movable, it is possible to prevent the press plate 27 fixed on the shaft 29 from deforming and is possible to bond the upper substrate 1b held on the press plate 27 and the lower substrate 1a held on the table 9 with maintaining both substrates in parallel.

[0018]

In drawing, the reference number 23 denotes a vacuum valve and the reference number 24 denotes a pipeline hose. The pipeline hose 24 is connected a vacuum source. The vacuum valve 23 and the pipeline hose 24 are used to decrease the pressure of the vacuum chamber to a vacuum state. In addition, the reference number 25 denotes a gas purge valve and the reference number 26 denotes a gas tuner. The gas tuner 26 is connected to a pressure source such as N_2 or clean dry air and the like. The gas purge valve 25 and the gas tuner 26 are used to restore the vacuum chamber to an atmospheric pressure.

[0019]

The upper substrate 1b is fixed and held on the lower surface of the press plate 27 but it is configured to be

held by means of the vacuum absorption under an atmospheric environment. Here, the reference number 41 denotes an absorption joint and the reference number 42 denotes a plurality of absorption tubes. The absorption tubes 42 are connected to a vacuum source and at the surface of the press plate 27, a plurality of absorption holes connected thereto are provided.

[0020]

Now, a description will be mad to the electrostatic absorption means.

[0021]

The press plate 27 has two square shaped hollow parts at its bottom surface. Each of the hollow parts contains a parallel plate electrode that is covered with an insulator. The main surface of the insulator is in the same plane as the bottom surface of the press plate 27. The buried parallel electrodes are respectively connected to the positive and negative direct current source via a suitable switch mechanism. Therefore, when a positive or negative voltage is applied to each of the parallel plates, negative or positive charges are induced at the main surface of the insulator that is in the same plane as the bottom surface of the press plate 27. With these charges, a coulombs' force is generated between the transparent electrode films of the upper substrate 1b and the upper substrate 1b is electro-

statically absorbed by the coulombs' force. The voltage applied to each of the parallel electrodes may have same or different polarities. Moreover, in atmospheric environment, the vacuum absorption may be used in combination to the electrostatic absorption. Also, when the electrostatic absorption force is prevailing, the vacuum absorption means may not be required.

[0022]

By the way, the shaft 29 is fixed to the housing 31 and 32. The housing 31 is attached with respect to the frame 30 by means of the linear guide 34. The press plate 27 is configured to be movable in vertical directions. Here, the vertical movement is accomplished by means of motor 40 that is fixed to the bracket 38 on the frame 35 connected by the frame 3. The transmission of the movement is accomplished by means of ball screw 36 and nut housing 37. The nut housing 37 is connected to the housing 32 through the load measuring unit 33 and operates integrally with the press plate 27 at the lower side of that.

[0023]

Therefore, as the shaft 29 is lowered by the motor 40, the press plate 27 that contains the upper substrate 1b is lowered. Then, the upper substrate 1b is attached to the lower substrate 1a on the table 9 such that it is constructed to make it possible to provide the press

pressure necessary to the bonding thereof. In this case, the load measuring unit 33 serves as a pressure sensor and controls the motor 40 based on the feedback signals such that it is made possible to provide a desired pressure to the upper and lower substrate 1a and 1b.

[0024]

Since the lower substrate 1a is mounted in a gravity direction, as shown in Fig. 2, the position of the lower substrate 1a is easily determined by pressing the position determination member 81 in a horizontal direction by means of a press roller 82.

[0025]

However, when determining a precise position thereof before the bonding process, it is likely that the upper substrate 1b rises or it is misaligned with the lower substrate 1a from the influence where the upper substrate 1b is made to be contact with the seal agent on the lower substrate 1a or the liquid crystal agents. Otherwise, it is likely that the upper substrate 1b is misaligned with the lower substrate 1a from the influence where the air inhaled in between the lower substrate 1a and the upper substrate 1b is leaked in the process of depressing the vacuum chamber. Therefore, the electrostatic absorption function is also provided to the table 9. Moreover, by providing the table 9 with a pin that is movable in Z axis directions and making

the pin being grounded, it is possible to prevent the bonded substrates from being charged and to facilitate the separation from the table 9.

[0026]

In Fig. 2, reference number 60 denotes a catch claw that is located in two of the diagonal positions of the upper substrate 1b and is suspended by the shaft 59 elongated downward. The catch claw in configured to catch the upper substrate 1b at a position slightly below the press plate 27 when the upper substrate 1b is falling because the vacuum absorption force is scarce as a result from that the press plate 27 performs a vacuum absorption and the vacuum chamber is depressed. Though not specifically depicted in drawing, the shaft 59 is configured to be movable in vertical directions and be rotatable because it is vacuum-sealed through the upper chamber unit 21. In addition, the shaft 59 is configured to be able to move vertically independent from the vertical movement of the press plate 27, but also to be rotated by means of the rotational actuator, such that the catch claw 60 disperses the liquid crystal in a direction where the main surface of the substrates 1a and 1b is dispersed, or retract the liquid crystal in a way that the bonding process is not hindered in future.

[0027]

Next, a description will be given to the method for assembling the substrates by using the substrate assembly apparatus described above.

[0028]

First, a jig holding the upper substrate 1b is mounted on the table 9 and the X, Y, theta stage T1 is moved to the substrate bonding part S2 by using the driving motor 5. Then, the press plate 27 is lowered through the shaft 29 by using the motor 40, the upper substrate 1b on the table 9 is vacuum-absorbed and thereafter is raised by the motor 40 such that the upper substrate 1b is revealed in atmosphere environment.

[0029]

Then, the X, Y, theta stage T1 is returned to the liquid crystal dropping part S1, and the empty jig is removed. After that, the lower substrate 1a is mounted on the table 9 such that it is held and fixed at a desired position as shown in Fig. 2.

[0030]

Though not shown in Fig. 1, because a dispenser that discharges the seal agents are disposed at the frame 3 that is near the dispenser 17 which discharges and loads the liquid crystal agents, the dispenser discharges the seal agents as the lower substrate 1a is moved in XY axis directions by each motor 5 and 6 of the X, Y, theta stage T1,

such that the seal agents are drawn in closed patterns on the lower substrate 1a.

[0031]

Thereafter, the liquid crystal agents are loaded from the dispenser 17 to the lower substrate 1a.

[0032]

Following this, the X, Y, theta stage T1 is moved to the substrate bonding part S2 at a height where the bottom surface of the upper substrate 1b holing the press plate 27 is made to be contact to the liquid crystal agent on the lower substrate 1a.

[0033]

The liquid crystal agent is expanded by the surface tension at about several millimeter height. In contrast, the seal agents are at about 20 micron. Therefore, the upper surface 1b does not contact with the seal agents and thus is sufficiently able to contact with the liquid crystal agents.

[0034]

Next, with a reference to Fig. 3, a description will be made to the process for dispersing the liquid crystal agents in a direction where the main surface of the lower substrate 1a is dispersed.

[0035]

The left side of Fig. 3 shows the positional relation

of both substrates 1a and 1b and the right side of Fig. 3 is an enlarged plan view of one location of the liquid crystal agents (P) on the lower substrate, where a solid line shows the present state and a dotted line shows the previous state.

[0036]

The left side of Fig. 3a shows a state where the liquid crystal agents (P) are applied on the lower substrate 1a. At this state, one location of the liquid crystal agents will be denoted by P1.

[0037]

The upper substrate 1b is lowered and is made to contact with the liquid crystal agent (P) at its bottom surface. By further lowering the upper substrate 1b, the liquid crystal agents is pressed and dispersed like P2 as shown in right side of Fig. 3b.

[0038]

In a state where the upper substrate 1b is contacted with the liquid crystal agents, the X, Y, theta stage T1 is moved from initial contact position to X axis + direction, X axis - direction, the initial contact position, Y axis + direction, Y axis - direction, respectively, as shown in Figs. 3c to 3g.

[0039]

When the X, Y, theta stage T1 is moved for example to X axis + direction, the liquid crystal agents is dispersed in

X axis + direction as indicated by P3, due to the adhesion to the upper substrate 1b.

[0040]

Likely, in Fig. 3d and after, when the lower substrate 1a is moved to each of X and Y directions with respect to the upper substrate 1b by the X, Y, theta stage T1, the liquid crystal agents is dispersed in a rectangular shape having a line corresponding to the traveling distance of the X, Y, theta stage T1, as indicated by P4 to P6. As the liquid crystal agents is dispersed, the thickness thereof becomes thinner and thus the press plate 27 is smoothly lowered. But the bottom surface of the upper substrate 1b does not contact with the seal agents provided on the lower substrate 1a. In other words, the application height of the seal agents, the application height of the liquid crystal agents, the distance between corresponding plane of both upper and lower substrates 1a and 1b can be known from the data that are inputted to the device. Further, because the upper and lower substrates are vacuum-absorbed in parallel, while the press plate 27 is lowered by the motor 40 to the extent that the bottom surface of the upper substrate 1b does not contact with the seal agents and thereafter the upper and lower substrates are moved respectively to X and Y direction, the traveling distance of the press plate is managed such that it does not destroy the shape of the seal

agents.

[0041]

In this way, the liquid crystal agents are sufficiently dispersed into the seal agents' pattern and the bonding process is performed thereafter.

[0042]

Then, the upper chamber unit 21 is lowered by the cylinder 22 and the flange part 21a is abutted to the O ring 44 such that the upper chamber unit 21 forms a vacuum chamber with the lower chamber unit 10. Thereafter, the vacuum chamber is depressed by releasing the vacuum valve 23. At this instance, because the upper substrate 1b is vacuum-absorbed to the press plate 27, as the depressing goes on, the vacuum absorption force with respect to the upper substrate 1b becomes weaker and as a consequence the upper substrate 1b falls by it's weight. The falling upper substrate 1b is received by the catch claw 60 as shown in Fig. 2, and is held slightly below the press plate 27.

[0043]

At time when the vacuum chamber is sufficiently made vacuum state, a voltage is applied to the electrostatic absorption means of the press plate 27 such that the upper substrate 1b on the catch claw 60 is held on the press plate 27 by the coulombs' force. In this case, because the vacuum chamber is already in a vacuum state, the air is not

resident between the press plate 27 and the upper substrate 1b, and in turn the upper substrate 1b do not floating when the air is leaked.

[0044]

Thereafter, the shaft 59 is lowered by means of elevating actuator not shown in drawing and then is rotated by means of rotating actuator. After making sure that the catch claw 60 does not disturb the bonding process of the upper and lower substrate, the press plate 27 is further lowered by using motor 40 and the bottom surface of the upper substrate 1b is contacted with the aid of the seal agents on the lower substrate 1a. And then, while measuring the applied pressure on the seal agents by means of the load measuring unit 33, the motor 40 is controlled to bond the upper and lower substrates 1a and 1b at desired distance therebetween.

[0045]

In this case, because the upper substrate 1b is attached to the press plate 27 and the central part of the upper substrate 1b does not sag, it does not have bad influence to the spacer in the liquid crystal agents or does not deteriorate the alignment of both substrates. Further, the alignment is accomplished by reading out a alignment mark provided to the upper and lower substrates 1a and 1b by using image recognition camera from a peep provided on the

upper chamber unit 21 and calculating the position of the readout alignment mark by means of image processing, and performing the high precision alignment while gently moving each stage 4a to 4c of the X, Y, theta stage T1. When moving the stages, the ball bearing 87 maintains the distance between the upper and lower chamber unit 10 and 21 so that the O ring 44 does not excessively deform and maintain the vacuum state.

[0046]

Upon completion of the bonding process, the vacuum valve 23 is closed and the gas purge valve 5 is released. Then, the chamber is supplied with N_2 or clean dry air and returned to atmospheric pressure. Thereafter, the gas purge valve 25 is closed and the upper chamber unit 21 is raised by means of the cylinder 22. The X, Y, theta stage T1 is thereafter returned to the liquid crystal dropping part S1 and the bonded substrates are separated from the table 9 and prepared for the subsequent bonding process. After separated from the table 9, the seal agents on the substrates are cured by means of UV irradiation device or heating device at downstream side.

[0047]

In the embodiment described above, because the bonding process can be started right after the liquid crystals are dropped by discharging the seal agents, particles are not

likely to adhered to the substrate and it is thus possible to improve the yield of product. In addition, because the X, Y, theta stage T1 can be used in conveying the upper substrate 1b into the vacuum chamber, it is possible to facilitate the small sized devices. In particular, because the liquid crystal agents are dispersed with the substrates held at the X, Y, theta stage T1, it is possible to decrease the number of items supplied to one substrate and the deviation of the supply amount become smaller. Furthermore, the dispersion of liquid crystal agents is performed at each bonded substrate, the supplying process can proceed to the bonding process in a short time and the productivity thus is improved.

[0048]

Moreover, because the liquid crystal agents can be supplied with by an accurate amount, the liquid crystal agents are not likely to overflow outside the seal agents pattern to contaminate the substrate, and, at the same time, the wash process are not required, so that it is possible to reduce the useless consumption of the liquid crystal agents.

[0049]

The present invention is not limited to those embodiments described above, but may be practiced as follows:

[0050]

(1) The liquid crystal agents applied on the lower substrate 1b may be for example a linear shape and the like, other than the dot shape. In such case, the liquid crystal agents can be dispersed by merely relatively moving those substrates in elongated direction and vertical direction with respect to each other.

[0051]

(2) The direction of moving those substrates relative to each other in dispersing the liquid crystal agents, may be a circular direction or a spiral direction as long as the liquid crystal agents do not exceed the seal agents patterns.

[0052]

(3) The upper substrate 1b may be absorbed to the press plate 27 directly from the robot arm.

[0053]

[Effect of the Invention]

As described above, according to the method for assembling liquid crystal substrate of the present invention, the supplied quantities of the liquid crystal agents are maintained.accurate, the dispersion time of the liquid crystal agents is made short, and the liquid crystal substrates are bonded in short time, thereby making it possible to enhance the productivity of the liquid crystal substrate.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a schematic diagram illustrating a substrate assembly apparatus that is embodying an embodiment of the present invention.

[Fig. 2]

Fig. 2 is a perspective view illustrating a state where the upper and lower substrates are bonded each other.

[Fig. 3]

Fig. 3 is a diagram illustrating the process steps for dispersing the liquid crystal agent applied on the lower substrate by moving the upper substrate.

[Reference Numerals]

1a: lower substrate

1b: upper substrate

9: table

10: lower chamber unit

17: dispenser

21: upper chamber unit

23: vacuum valve

27: pressing plate

T1: XYθ stage

S1: liquid crystal dropping part

S2: substrate bonding part